

Ambient Sediment Toxicity Assessment

December 9, 2004

Handout # 4

Sediment toxicity is one of the many water quality indicators used in assessing overall surface waterbody condition. Sediment toxicity in conjunction with other water quality information may be used to make determinations of water quality standards attainment. The collection of ambient sediment toxicity data is not intended to become a “hunt” for noncompliant water bodies for inclusion on the 303(d) list of impaired waters. Sediment toxicity collection is to be conducted as a methodical process to examine specific water bodies where concerns have been expressed or are likely candidates for further investigation. For this reason, quarterly routine sediment toxicity sampling will not be conducted. Ambient sediment toxicity assessments will examine the spatial and temporal relationship between pollutants, observed toxicity, and resident biological communities. All site information will be integrated into a weight of evidence approach to best judge the condition of the area in investigation.

Weight of Evidence

Ambient sediment toxicity assessment is formulated upon multiple lines of evidence to reach a decision on risk characterization leading to risk management.

The framework by which ambient sediments are to be assessed is considered a weight of evidence approach. This is commonly defined as a determination related to possible ecological impacts based upon multiple lines of evidence. This determination incorporates judgments concerning the quality, extent and congruence of the data contained in the different lines of evidence (Chapman *et al.* 2002).

Evidence considered for determining ecological risk of areas assessed for ambient sediment toxicity will include: whole sediment toxicity test results, elutriate toxicity test results, biological community data, contaminant concentrations. The decisions will be supported by the interpretation of the data which will include the use of Best Professional Judgement (BPJ), as discussed below and illustrated in Table 1.

Example: A waterbody will likely be considered impaired or a concern for ambient sediment toxicity if whole sediment tests indicate a problem, even if the three other lines of evidence indicate no chemical or biological impairment. On the other hand, a waterbody may or may not be listed as an impairment or concern if whole sediment toxicity data indicate no adverse affects but the other three lines of evidence demonstrate a problem. In both of these scenarios, BPJ will be the deciding factor.

Each line of evidence used in the ecological risk assessment leading to decisions on impairment of the water body has strength, weakness, and limitations in data collection and interpretation. These factors for each parameter must be considered and weighted accordingly in the

assessment. Each of the assessment parameters is discussed for the strength and weakness of the line of evidence.

Sediment Toxicity: Sediment toxicity tests provide direct information on the effects of a site sediment upon a representative benthic species. In these tests, sediment collected from ambient sites is populated with benthic organisms (typically midges and/or amphipods) in a laboratory setting. The sediment may exhibit toxicity from chemicals present, physical textural conditions, invasive predatory organisms, ammonia, chlorides, high sediment oxygen demand, pathogens, etc. It is the objective of the test assessment in the laboratory to eliminate superfluous information such as unexpected predation from transient organisms in the sediment or adverse environmental conditions. The laboratory sediment tests typically utilize whole sediment and are placed into test containers and covered with laboratory water, which should closely mimic site water conditions for physical and chemical integrity. For purposes of assessment in the SWQM program, the test duration is usually not longer than 10 days and measures survival and growth. Longer tests can be conducted that include measurements of survival, growth (length/weight) and reproduction. However, longer tests do not necessarily add more information to the assessment since at the ten-day exposure most chemicals have reached equilibrium in biological tissue and have had effects on survival if concentrations and subsequent dosing are at toxic thresholds. Sediment tests should be supplemented with all available data on site conditions and water/sediment quality to enable judgment in interpretation of the results. Sediment texture, organic carbon, pH, acid volatile sulfides (AVS), etc. are important in understanding the presence or absence of sediment toxicity. A review of the factors to consider in estuarine systems is reviewed by Chapman and Wang (2001)

Elutriate toxicity: In these tests, sediments are vigorously mixed with laboratory test water for a specified period of time, the laboratory test water is then siphoned off and water column test organisms (typically minnows and/or water fleas) are introduced to the test water (the elutriate) in the absence of sediments. Contaminants associated with the sediments would thus be transferred to the water, increasing the level of exposure of the aquatic organisms to pollutants. These tests are useful for representing the exposure to chemicals that can occur after sediments have been resuspended into the water column or after they have passed through the water column as part of dredged material disposal operations. In terms of assessing ambient sediment toxicity elutriate tests have been the subject of considerable debate as to their utility.

Sediment chemistry: Sediment chemistry may be indicative of toxic sediments if the chemicals present are responsible for toxicity. Ideally, elevated levels of chemicals should coincide spatially and temporally with observed toxicity. The chemical analyses should be structured to identify toxicants such as ammonia, which may be naturally occurring, or substrate texture that is physically harmful to test organisms. Chemistry can be compared to screening benchmarks for indications of relative sediment quality. Another approach may be to determine “toxic units” of sediment based upon chemical concentrations and use an approach such as equilibrium partitioning and presence of AVS (for metals) to account for expected toxicity or lack thereof.

Benthic community: In the presence of well defined indices of integrity, direct measurement of the health of the biological community can be made at the site of interest. This is an important line of evidence for evaluating potential toxicity. Prevailing conditions such as ambient water temperature and salinity can affect the community more than chemical stressors. The estuarine environment is more challenging to biological communities than some of the more traditional freshwater streams or offshore environments. The benthic community analysis is indicative of ambient conditions and must be compared to reference conditions that have been firmly established using similar indices. Without established guidance, benthic data is subject to considerable BPJ. Established indices that are indicative of the condition of environmental health are preferred. For many ecosystems a defensible index with adequate reference conditions and site comparisons that can be used to determine biological condition are lacking. If such metrics were available and agreed upon, benthic analysis would deserve considerable weight of evidence in any site assessment.

Best Professional Judgement

BPJ comprises the use of expert opinion and judgement based on available data and site-and - situation specific conditions to determine, for example, environmental status or risk. BPJ can be initiated in cases where there are extensive data but few uncertainties, and in cases where there are few data and many uncertainties (Chapman *et al.* 2002).

The use of ambient toxicity tests is an evolution. Current tests are subject to interpretation and failures may not always be useful or accurate for identifying toxic conditions.

For the assessment of ambient toxicity in sediment, BPJ will support other lines of evidence to provide final determinations of use support. In many cases, BPJ will provide insight to site specific conditions, biological assessment methodologies, toxicological test conditions and pollutant analyses.

Whole Sediment Toxicity Tests

Whole sediment toxicity tests should provide the most useful information for assessing ambient toxicity for the following reasons:

1. Test organisms used are endemic to benthic habitats
2. Test conditions best represent ambient conditions

Approved Methods

The following methods are approved....XXXXXXXXX ASTM...

Considerations

- ! Adverse conditions during the test (presence of predatory organisms, high ammonia levels).
- ! Procedures employed, including modifications to standard protocols. Modifications to existing methods must be well documented within the published method and well described. Applications for alternate testing procedures will be made to the executive director.
- ! Adverse conditions during the test (presence of predatory organisms, high ammonia levels).
- ! Temporal and spatial distribution of the samples which are representative of the assessment area.
- ! Porewater samples - Do these indicate elevated levels of pollutants?
- ! Methods used - including modifications to standard protocols.
- ! Confounding affects of other constituents - AVS, total organic carbon (TOC), grain size.
- ! Although tests may be performed, confounding affects may render the results inconclusive. In this situation much of the ambient sediment toxicity assessment would rely on BPJ.

Evidence of Toxicity:

The presence of toxicity is demonstrated primarily by lethal and/or sublethal effects on benthic organisms used in the tests. The evidence of toxicity will depend exclusively on the toxicological endpoint of the tests employed. The assessment of lethal toxicological endpoints for the typical 10 day test will employ an alpha level of 0.05. The level of confidence for sublethal effects on test organisms must be greater, and when assessing sublethal endpoints for the same duration test, an alpha level of 0.01 will be used.

Elutriate Toxicity Tests

Results of these tests should be considered a weaker line of evidence when evaluating ambient sediment toxicity. The following aspects should be considered when using elutriate tests to evaluate ambient toxicity:

1. These tests were developed to evaluate the effects of dredge disposal on aquatic organisms. Sediment used in this method is prepared in a way which is not representative of ambient conditions (samples are often shaken for 24 hours). However, these tests may represent conditions experienced under high flow events where substantial amounts of sediment resuspension may occur.
2. These tests are conducted on water column organisms and may or may not indicate effects to actual benthic organisms.

Approved Methods

The following methods are approved....XXXXXXX

Considerations

- ! Test organisms used in the tests.
- ! Procedures employed, including modifications to standard protocols. Modifications to existing methods must be well documented within the published method and well described. Applications for alternate testing procedures will be made to the executive director.
- ! Temporal and spatial distributions of the tests.
- ! Confounding effects of other constituents - AVS, TOC, grain size.
- ! Sublethal toxicity should not be assessed.
- ! Samples results could be inconclusive which would provide a no available data result.
- ! Some contaminants are released under elutriate test conditions, but may not be bioavailable under ambient conditions.

Evidence of Toxicity:

The evidence of toxicity will depend exclusively on the toxicological endpoint of the test employed. The assessment of lethal toxicological endpoints for the 7 or 10-d test will employ an alpha level of 0.05.

Pollutant Concentrations

The level of pollutants in the sediment can be used to imply a cause for observed ambient toxicity. A Toxicity Identification Evaluation maybe necessary to identify a specific pollutant for load reduction (regulatory activity).

Considerations

- ! Screening levels used - PECs, PELs, ERM, ERLs, etc.
- ! Temporal and spatial distribution of the samples.
- ! Confounding affects of other constituents - AVS, TOC, grain size.
- ! Relative ranking to other similar waterbodies throughout the state.
- ! Sample results could be inconclusive

While acid volatile sulfide/simultaneously extracted metals (AVS/SEM) is understood to be a geochemically feasible method to predict the potential biological availability of metals found in sediments, it is necessary to recognize that this technique is also bound by a number of assumptions and limitations. These include: the high potential for changes in sediment geochemistry to occur; the fact that most benthic invertebrates tend to concentrate in the oxidized sediments where occurrence of sulfides is not favored; the method does not consider the ingestion of sediment by receptors; and that the methodology is only applicable in anaerobic sediments and for a limited number (five) of metals. Additional limitations of this methodology

are discussed in an article in the SETAC Globe (The Acid Volatile Sulfide Side of the AVS-SEM Method for Assessing Sedimentary Metal Toxicity. Pages 48-50. July-August 2004). It would be inappropriate to use this method to make any assertions regarding potential risks to organisms exposed to sediments containing metals without considering these limitations. Since the method only applies to some sediments, at some times, for some metals, it is suggested that AVS/SEM be used conservatively.

Biological Communities

Biological integrity can be used to evaluate the impacts of ambient toxicity

Considerations

- ! Communities assessed - nekton or benthos.
- ! TCEQ's Index of Biotic Integrity, used to evaluate aquatic life use support in wadeable streams, may not be sensitive enough to demonstrate toxicity to sensitive species or life stages.
- ! Biological integrity assessment methods - Are there accepted indices by which to assess biological communities? There are currently no established methods for estuarine and reservoir benthic biological integrity.
- ! Samples results could be inconclusive which would provide a no available data result.

Applicability of Ambient Sediment Toxicity to Intermittent Streams (*without perennial pools*)

In order for ambient sediment toxicity to be relevant, the aquatic community must be exposed and affected. Areas that are evaluated for toxicity should have overlying water and an established benthic community.

Table 1: Relative weights of lines of evidence for sediment toxicity					
Whole Sediment Tests indicate toxicity	Elutriate Tests indicate toxicity	Biological Community Indicates Effects of Toxicity		Level of Contaminants Indicates Potential for Toxicity	BPJ
		established IBI	no established IBI		
50	10	25	10	10	10 or -10
Aquatic Life Use Impairment if > 50 Concern if >15 to 45 No Concern, unassessed or limited data if <= 15					
BPJ cannot equal 0 If BPJ indicates toxicity then value will be 10 If BPJ indicates a lack of toxicity or problems with a specific line of evidence then value will be -10					

Example 1:

Line of Evidence	Result	Points
Whole Sediment Tests indicate toxicity	No	0
Elutriate Tests indicate toxicity	No data	0
Biological community indicates effects of toxicity (established IBI)	Yes	25
Level of Contaminants Indicates Potential for Toxicity	Yes	10
BPJ (no toxicity in whole sediment tests)		-10
	Total	25
Water Quality Concern for Ambient Toxicity in Sediment		

Example 2:

Line of Evidence	Result	Points
Whole Sediment Tests indicate toxicity	No data	0
Elutriate Tests indicate toxicity	Yes	10
Biological community indicates effects of toxicity (no established IBI)	Yes	10
Level of Contaminants Indicates Potential for Toxicity	Yes	10
BPJ (levels of contaminants in sediment ranked as highest in the state for that waterbody type. Additional whole sediment tests will confirm or refute impairment)		10
	Total	40

Line of Evidence	Result	Points
Water Quality Concern for Ambient Toxicity in Sediment		

Example 3:

Line of Evidence	Result	Points
Whole Sediment Tests indicate toxicity	Yes	50
Elutriate Tests indicate toxicity	No data	0
Biological community indicates effects of toxicity (no established IBI)	No	0
Level of Contaminants Indicates Potential for Toxicity	Yes	10
BPJ (toxicity tests and contaminant levels indicated toxicity)		10
	Total	70
Aquatic Life Use Impairment for Ambient Toxicity in Sediment		